Antimatter-Initiated Microfission/ Fusion: Concept, Missions, and Systems Studies for Exploration of Deep Space

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Fig.1 Side view illustration of the AIMStar reaction trap

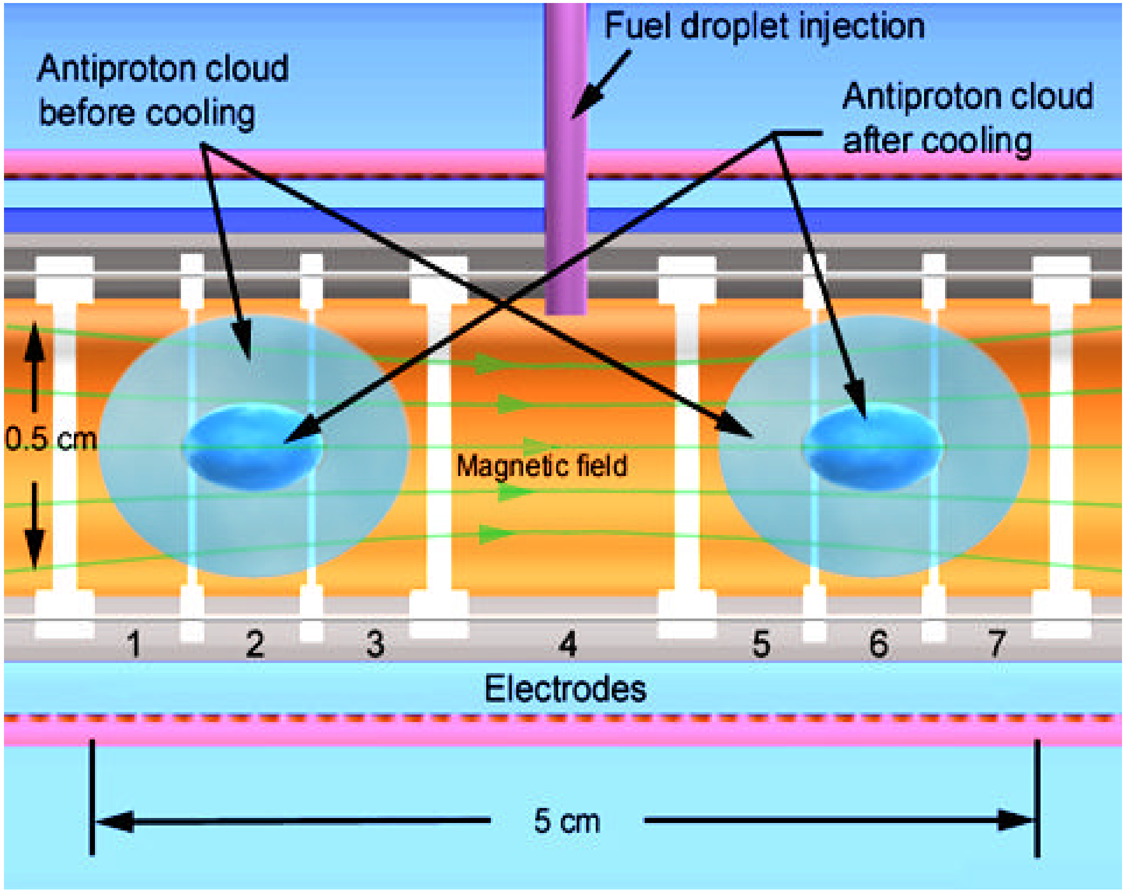


Fig.2 Chronological illustrations of the AIM process. Fuel is injected in Figure (a) and enters the cloud and annihilates with 5 x 10^8 antiprotons in (b). A weak-nested potential well is used to separate the charged species as shown in (c), and a 600 keV potential is applied to spark microfusion, as shown in (d).

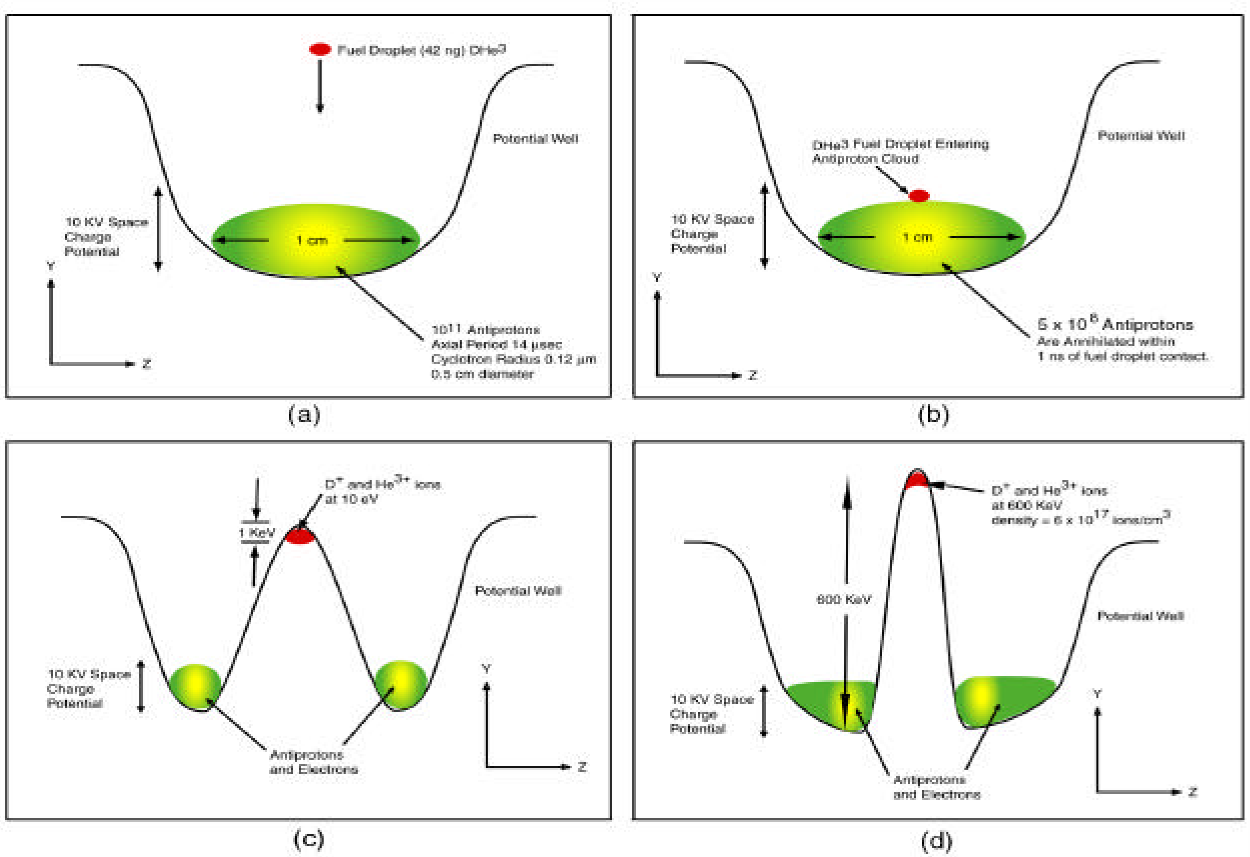


Fig.3 Original configuration of the ICAN-II Spacecraft

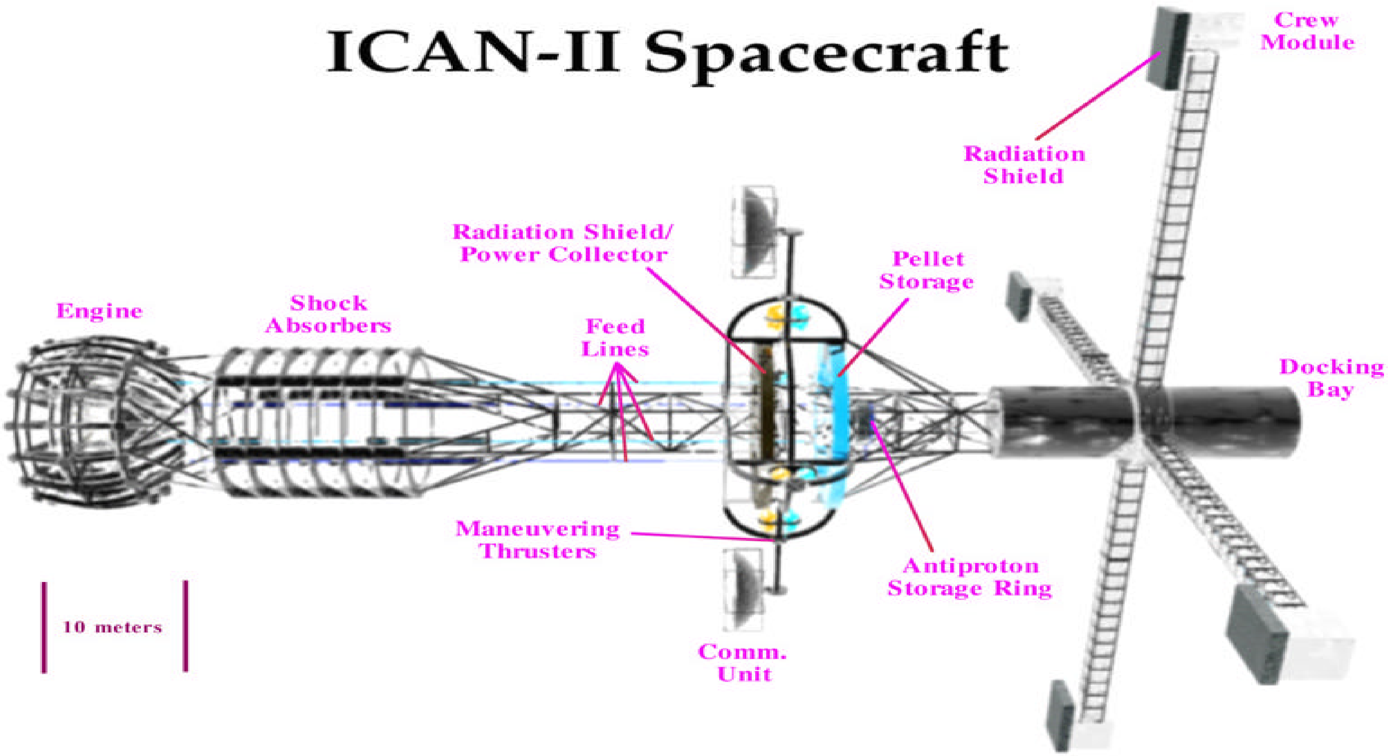
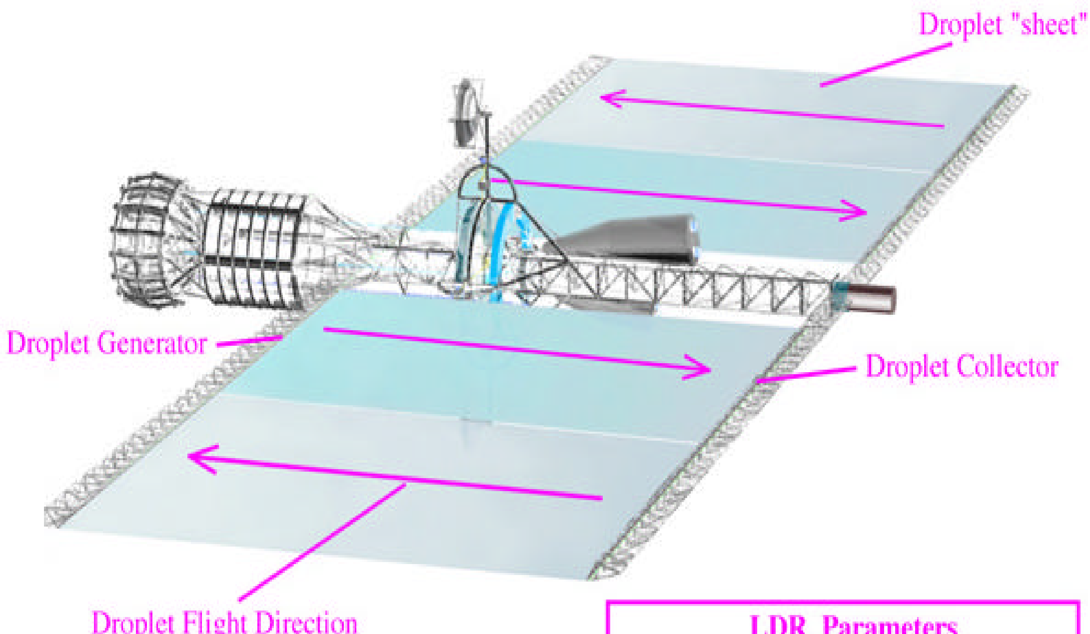


Table 1. Estimate of ICAN-II Vehicle Masses for 120 day, DV = 100 km/s Mars Mission (RT)

Component	Mass (metric tons)
Ion Driver	100
Engine Structure	27
Spacecraft Structure	30
Antiproton Traps	5
Neutron Shielding	45
Power Processing	58
Payload on ICAN	20
Mars Lander/Surface Payload	53
Mars Mission Ascent Vehicle	9
Total Dry Mass	347
Mass of Silicon Carbide Thrust Shell	362
Total Mass of ICAN	709

Fig.4 ICAN-II with Liquid Droplet Radiator Deployed



LDR Parameters	
Power ejected	60 MW
Approximate size	64 m x 190 m
Droplet material	Liquid lithium
Ejected temperature	589 K
Collected temperature	487 K

Fig.5 Profile of the AIMStar spacecraft

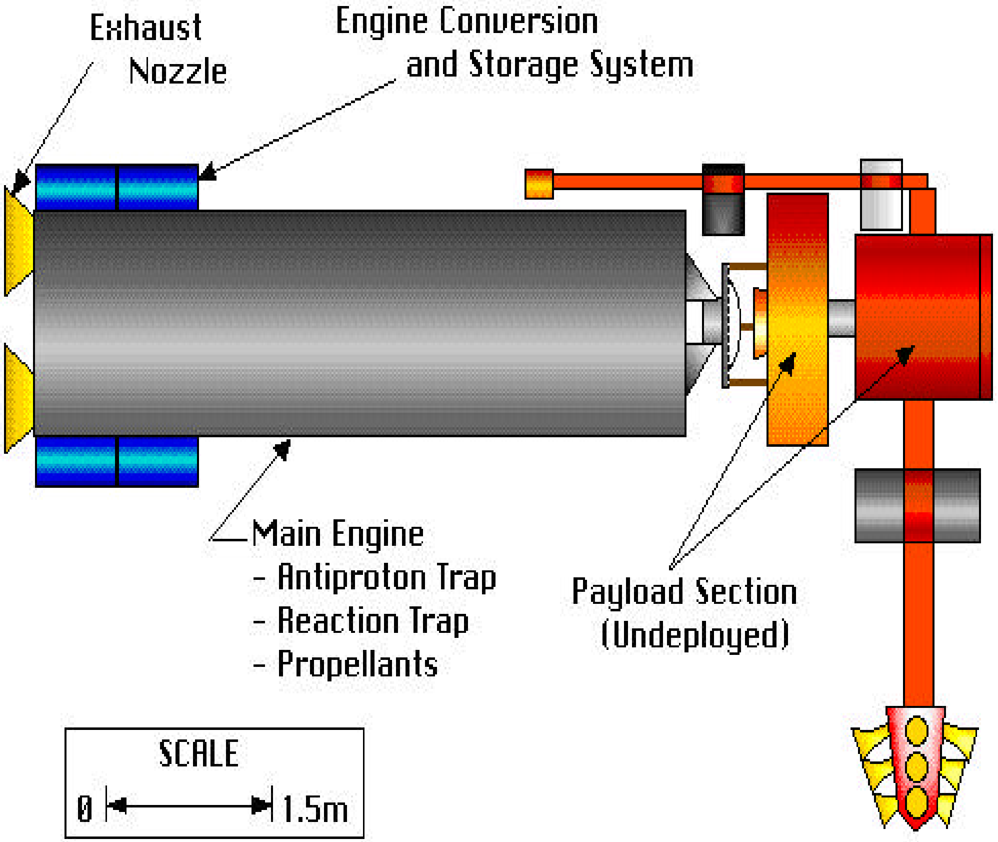


Table 2. AIMStar 50-year Mission to 10,000 A.U

Parameters	DT	DHe^3
ΔV	956 km/s	956 km/s
V_e	$5.98 * 10^5$ m/s	$5.98 * 10^5$ m/s
I_{sp}	61,000 s	61,000 s
Power	33 MW	0.75 MW
Thrust	55.2 N	1.25 N
dm/dt	$9.22 * 10^{-5}$ kg/s	$2.09 * 10^{-6}$ kg/s
t_b	0.50 yr = 6 mo.	22 yr
Distance @ burnout	37 AU	1635 AU
α_{ave}	30.5 kW/kg	0.69 kW/kg
N_{pbar}	130 μg	28.5 μg

Fig.6 Density and speed contours of Li^+ expansion at 2 msec with B = 0.2 T, r_o ~ $1x10^{-4}$ kg m^{-3}, and T_o = 10 eV

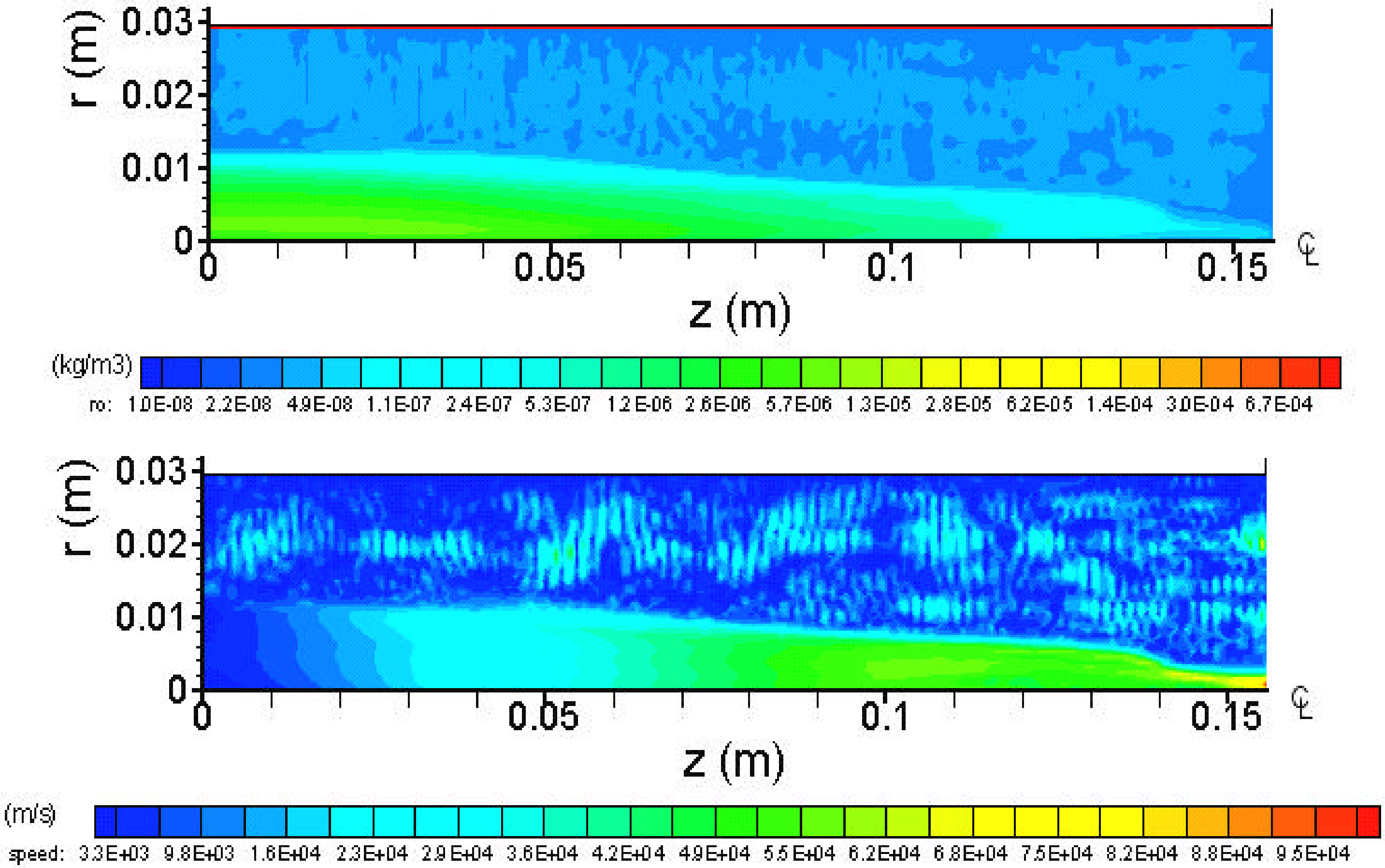
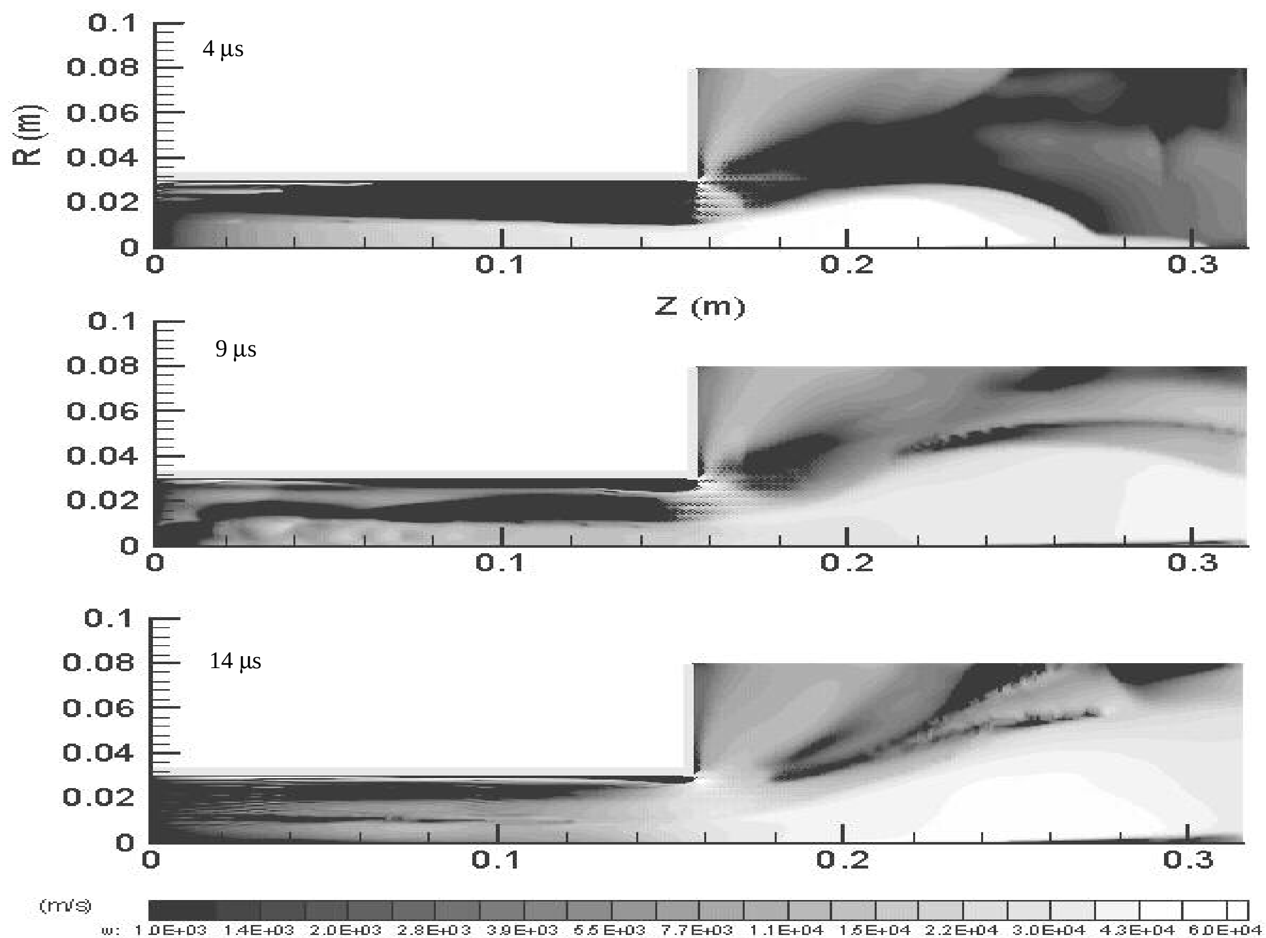


Fig. 7 Axial velocity contours at 4, 9, and 14 ms with B = 0.2 T magnetic poloidal nozzle



Summary

Antimatter is the most energetic reaction known in physics and can be used to extend space missions to interstellar distances. Concepts such as ACMF and AIM may reduce antimatter requirements to minimal levels in the near future, ensuring cost efficiency and availability for near-interstellar missions. We are actively studying ways of storing and utilizing antimatter for space propulsion applications and have begun to outline development roadmaps for future work. In particular, a propulsion demonstration utilizing the AIM concept with a LiH fuel can provide a preliminary step towards the advent of antimatter-catalyzed microfusion, and its 5800 sec. specific impulse and 35 mN thrust can be readily measured. These studies and others are required as stepping-stones to eventually design and build an antimatter-powered spacecraft.